Appendix D

Zero-Discharge Demonstration

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Technical Memorandum

To: Christie Kearney and Jennifer Saran, Poly Met Mining, Inc.
From: Cory Anderson and Melisa Pollak, Barr Engineering Co.
Subject: Application of the New Source Performance Standards "Zero Discharge" Standard (40 CFR § 440.104) to the NorthMet Project
Date: June 20, 2016
Project: 23/69-0862.00

1.0 Introduction

Barr Engineering Co. (Barr) has determined that the proposed NorthMet Project (Project) can comply with the discharge requirements of the Clean Water Act (CWA) New Source Performance Standard (NSPS) for the ore mining and dressing point source category applicable to new copper processing facilities—referred to as the "zero discharge" standard. Specifically, the volume of water to be discharged from the proposed Waste Water Treatment Plant (WWTP) is not expected to exceed the volume allowed under the NSPS.

This memorandum summarizes the relevant law and facts, then presents the technical analysis supporting Barr's conclusion that the Project can comply with the NSPS. The memorandum employs terms for various types of water associated with the Project that are specifically defined in Poly Met Mining, Inc.'s (PolyMet) application for a National Pollutant Discharge Elimination System (NPDES) / State Disposal System (SDS) permit for the Project. Italicized terms are defined in Table 1-1 of Volume I of the NorthMet NPDES/SDS Permit Application. Additionally, the term "Flotation Tailings Basin" (FTB) refers to the proposed NorthMet Flotation Tailings Basin, which will be newly constructed atop the existing former LTV Steel Mining Company (LTVSMC) tailings basin. The term "Tailings Basin" refers more generally to the combined LTVSMC tailings basin and the FTB.

Barr understands that PolyMet plans to obtain NPDES/SDS permit coverage starting approximately 2 years before mine operations begin. In this case, Mine Year 1 will be the third year of NPDES/SDS permit coverage.

2.0 Legal Basis

In addition to the effluent limitations in 40 CFR §440, the proposed NorthMet discharge will be subject to the CWA's NSPS for the new copper mills and set forth in 40 CFR § 440. The applicable regulations and guidelines of the United State Environmental Protection Agency (USEPA) set forth a general prohibition against discharging process wastewater to waters of the United States[1] from new mills[2] that use the froth-flotation process for the beneficiation of copper, lead, zinc, gold, silver, and molybdenum ores (40 CFR § 440.104(b)(1)).[3] While this general prohibition is referred to as the "zero discharge" standard, the applicable law includes exceptions that allow a certain volume of discharge to account for specific conditions and does not prohibit discharge of mine drainage. This "zero-discharge standard" is based upon the USEPA assessment that total recycling of process wastewater at froth-flotation plants is a demonstrated and feasible technology.[4]

The terms "process wastewater" and "mine drainage" are specifically defined for the NSPS, and associated USEPA guidance provides additional insight on these terms. Table 1 provides these definitions and shows the corresponding NorthMet flows using the water terminology definitions for the NPDES/SDS Permit Application.

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[1] *See* 40 CFR § 440.104(b)(1) (prohibiting the discharge of process wastewater to "navigable waters") and 40 CFR § 401.11(l) (defining "navigable waters" as "waters of the United States, including the territorial seas"). Section 401.11(l) also provides the lengthy definition of "waters of the United States." This memorandum assumes that the Project receiving waters are "waters of the United States."

[2] "Mill" is defined as "a preparation facility within which the metal ore is cleaned, concentrated, or otherwise processed before it is shipped to the customer, refiner, smelter, or manufacturer. A mill includes all ancillary operations and structures necessary to clean, concentrate, or otherwise process metal ore, such as ore and gangue storage areas and loading facilities." (40 CFR § 440.132(f)) The Beneficiation Plant falls within this definition.

[3] 40 CFR §§ 440.100 to 440.105. The standards for new sources in this category are set forth in 40 CFR § 440.104. In the relevant part, the NSPS applies to: (a) mines that produce copper, lead, zinc, gold, silver, or molybdenum bearing ores, or any combination of these ores from open-pit or underground operations other than placer deposits; and (b) mills that use the froth-flotation process alone or in conjunction with other processes, for the beneficiation of copper, lead, zinc, gold, silver, or molybdenum ores, or any combination of these ores. 40 CFR § 440.100(a).

[4] USEPA, Proposed Ore Mining and Dressing Point Source Category Rule, 47 Fed. Reg. 25682, 25716 (Monday, June 14, 1982). In this preamble and in the zero-discharge standard itself, USEPA notes the agency's understanding that the zero-discharge standard could result in an increase of discharges to other media. *See* 40 CFR § 440.104(b)(1).

Table 1 Correlation of Water Terminology Between NSPS and NorthMet NPDES/SDS Application

NSPS term	NSPS definition	Corresponding NorthMet flows
Process wastewater	"Any water which, during manufacturing or processing, comes into direct contact with or results from the production or use of any raw material, intermediate product, finished product, by-product, or waste product." 40 CFR § 401.11(q)	*Process water*
Mine drainage	"Any water drained, pumped, or siphoned from a mine." 40 CFR § 440.132(h)	*Mine water*

As noted, the zero-discharge standard for process wastewater from new copper mills is subject to certain exceptions, two of which are relevant to the NorthMet Project:

1. Net precipitation can be discharged. A volume of water may be discharged equal to the annual net precipitation (precipitation minus evaporation) falling on the treatment facility and on the area contributing runoff to the treatment facility.[5]

[5] 40 CFR § 440.104(b)(2). "Treatment facility" is not defined, but USEPA's preamble to the regulations make clear that USEPA views a tailings basin as a treatment facility.

2. Combined waste streams that include process wastewater can be discharged, subject to limitations. Process wastewater can be discharged when it has been combined with other waste streams, such as mine drainage, that are not subject to the "zero discharge" standard. The volume and concentration of the combined discharge, however, may not exceed the volume and concentration of the allowable discharge of the other waste streams, and the combined discharge is subject to the NSPS effluent limitations for mine drainage.[6]

The NSPS set forth in 40 CFR § 440 does not establish timeframes for calculating either allowable discharge or actual discharge for purposes of the "zero discharge" standard. PolyMet proposes that the NPDES/SDS permit adopt a multi-year approach for calculating these volumes so as to take into account timing considerations relative to variability in weather conditions and timeframes for water treatment.

3.0 Overview of NorthMet Flows Relevant to the "Zero Discharge" Standard

The NorthMet Project will generate process wastewater in the Beneficiation Plant, but the discharge to the environment will occur later as treated effluent from the Waste Water Treatment Plant (WWTP). In between these steps, the process wastewater will be managed within the Tailings Basin. The link between process wastewater, illustrated in Figure 1, involves the following processes:

- The overall Project water management strategy involves pumping mine drainage to the FTB to serve as *process water* for the Beneficiation Plant. Process wastewater from the Plant will be recycled back to the FTB Pond, where it will mix with mine drainage and other waste streams. *Tailings basin water* will be a "combined waste stream" (40 CFR § 440.131(a)).

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[6] 40 CFR § 440.131(a). This provision provides: "In the event that waste streams from various subparts or segments of subparts in part 440 are combined for treatment and discharge, the quantity and concentration of each pollutant or pollutant property in the combined discharge that is subject to effluent limitations shall not exceed the quantity and concentration of each pollutant or pollutant property that could have been discharged had each waste stream been treated separately. In addition, the discharge flow from the combined discharge shall not exceed the volume that could have been discharged had each waste stream been treated separately."

Notably, USEPA's preamble and Development Document for the Ore Dressing NSPS addressed the Combined Waste Stream Provision in response to a commenter's question involving a situation almost identical to PolyMet's: whether mine drainage commingled with the process wastewater from a new froth flotation mill is subject to the zero-discharge requirements for new froth flotation mills. USEPA concluded that the mine drainage would not be subject to the zero discharge standard, even though the discharge would technically contain some process wastewater. In addition, USEPA noted that (a) the combined waste stream discharge would be subject to the effluent limitations for the mine drainage, and (b) the volume of the discharge could not exceed the volume of mine drainage that would have been discharged had the mine drainage and the mill discharge been treated separately. USEPA also clarified that it was immaterial "whether the mine drainage is introduced to the treatment system simultaneously with the discharge from the mill, e.g., two separate pipes leading to the tailings pond, or whether the mine drainage is introduced as part of the feed water and intake to the mill itself." *See* USEPA, Office of Water, Development Document for Final Effluent Limitations, Guidelines and New Source Performance Standards for the ore Mining and Dressing Category 507 (Development Document) (Reference (5)); 47 Fed. Reg. 5498, 54604 (Dec. 3, 1982) (Reference (4)).

- Some *tailings basin water* will infiltrate and migrate to the toes of the Tailings Basin dams as *tailings basin seepage*. PolyMet will install FTB seepage capture systems around the Tailings Basin that are designed to capture the *tailings basin seepage*.
- There will be a delay between the time water enters the FTB and the time that resulting seepage reports to the FTB seepage capture systems. GoldSim modeling for the FEIS indicates the time delay will be at least seven years.
- *Tailings basin seepage* captured by the FTB seepage capture systems will either be recycled to the FTB Pond or pumped to the WWTP for treatment. PolyMet will determine how much seepage to recycle back to the FTB Pond, and how much to send to the WWTP for treatment and discharge, based on factors such as weather, operational needs, FTB size, and regulatory and augmentation requirements (such as the "zero discharge" standard and the need to avoid hydrologic impacts to Second Creek, Trimble Creek, and Unnamed Creek).
- WWTP effluent, which will consist primarily of treated *tailings basin seepage*, will be discharged to the headwater areas of Trimble Creek, Unnamed Creek, and Second Creek.

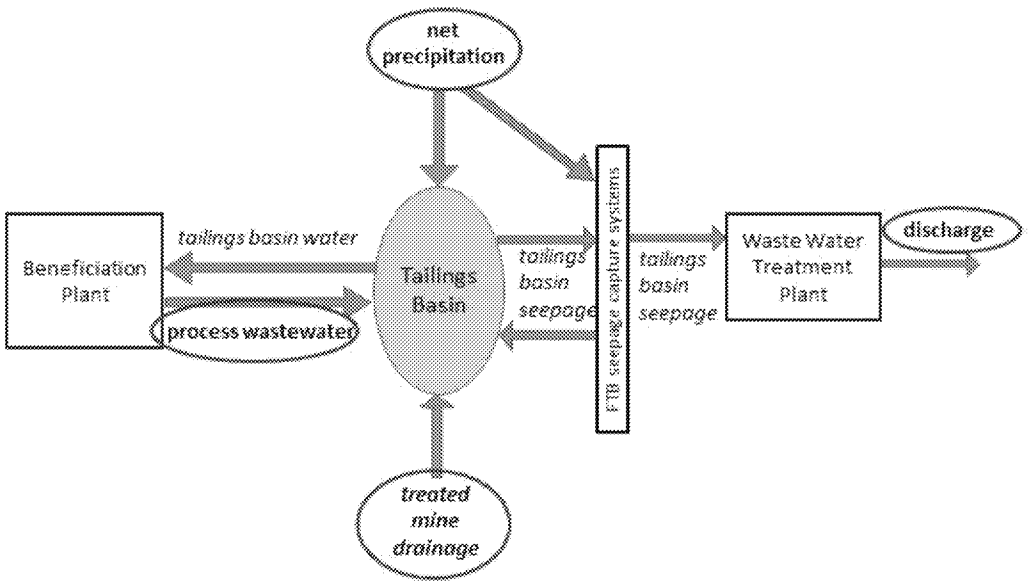

Figure 1 Overview of NorthMet Project Flows Relevant to NSPS Zero-Discharge Standard

4.0 Technical Analysis

The Plant Site GoldSim model developed for the FEIS (Reference (1)) was used as the starting point for analysis of the Project's ability to comply with the zero-discharge standard.

4.1 Calculating the "Allowable Discharge Volume"

Based on the Project-specific flows and applicable exceptions to the "zero discharge" standard described in Section 2.0, the volume that the Project may discharge can be calculated as the sum of 1) net precipitation and run-on over the Tailings Basin, and 2) the volume of other waste streams combined with process wastewater.

4.1.1 Net Precipitation

Net precipitation includes precipitation minus evaporation over the area of the Tailings Basin plus runoff into the Tailings Basin, runoff from the exterior slopes of the dams, and runoff from the small watershed area between the toes of the dams and the FTB seepage capture system. Net precipitation over other portions of the Plant Site are not included. Net precipitation will change as the FTB is expanded during operations. Areas included in net precipitation for the zero-discharge analysis are illustrated for Mine Year 11 in Figure 2 and described in the following paragraphs. Further details on the numeric values for each area are provided in Attachment B of Reference (1).

For the zero-discharge analysis, the areas used to calculate the precipitation inflow volume are the areas of exposed tailings in Cell 2W, Cell 2E, and Cell 1E, the areas of the north, east, and south beaches, the areas of the north, south, and east dams, the areas of the north and south buttresses, the area of the FTB Pond, and the area of the pond in Cell 1E (for Mine Years 1 through 7; after Mine Year 7, the FTB pond combines with the Cell 1E Pond). The rate of precipitation times the total sum of the areas is the total precipitation inflow rate. Run-on flows are from watershed areas contributing to Cell 1E and to Cell 2E, and the small watershed areas between the toes of the dams and the FTB Containment System.

Evaporation losses were calculated in a manner consistent with the FEIS model (Reference (1)). Because the evaporation rate (depth over time) from each area is unique, the volumetric evaporation rates were summed from each of the same areas listed in the preceding paragraph.

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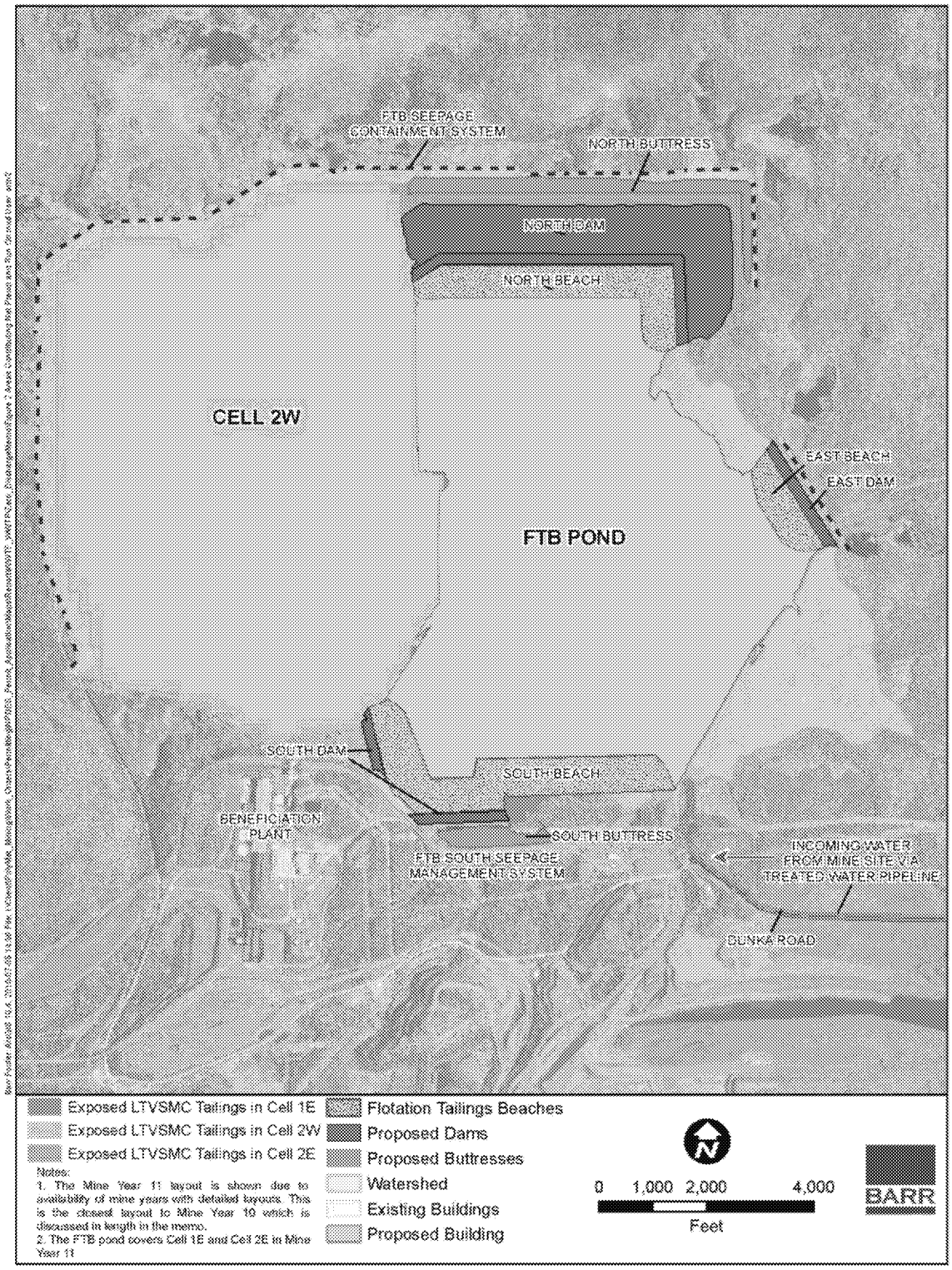

Figure 2 Areas Used to Calculate Net Precipitation for the Zero Discharge Analysis

4.1.2 Combined Waste Streams

Waste streams combined with process wastewater in the FTB Pond originate from five sources, but of these waste streams, PolyMet proposes to count only mine drainage toward the allowable discharge. Because of extensive water recycling, recirculated flows are excluded to avoid "double counting" in a way that would increase the calculated allowable discharge volume. Also for simplicity, PolyMet is excluding from its calculation certain de minimis additions to the FTB that are exempt from the "zero discharge" standard. The waste streams that will be combined with process wastewater in the FTB Pond, and their approximate flow in Mine Year 10, are presented in Table 2. The table also identifies whether PolyMet will count these flows toward the allowable discharge. Additional detail on the flows included in treated mine drainage is presented in Section 6.1 of the NorthMet Project Water Modeling Data Package Volume 1 – Mine Site (Reference (2)).

Table 2 Waste Streams Combined with Process Wastewater in the FTB Pond

Waste stream combined with process wastewater	Approximate annual P50 flow Mine Year 10[1]	Count toward allowable discharge?
treated mine drainage (total flow from CPS Pond to FTB)	1,750 gpm	Yes. Less the volume of WWTP reject concentrate
WWTP reject concentrate	118 gpm	No. Not included to avoid double counting.
tailings basin seepage	1,170 gpm	No. Not included to avoid double counting.
backwash waste from the WWTP	150 gpm	No. Not included to avoid double counting.
treated *sewage*	20 gpm	No. Not included for simplicity in reporting

(1) Flows are based on the 50th percentile (P50) flows from the FEIS GoldSim model (Section 6.1 of Reference (1))

4.1.3 Allowable Discharge Equation for Zero Discharge Analysis

Based on the analysis above, for reporting and modeling with respect to the zero-discharge standard, the allowable discharge is calculated as follows:

Allowable Discharge = net precipitation + treated mine drainage[7] – WWTP reject concentrate

Figure 3 illustrates in further detail the Project flows relevant to calculation of the maximum allowable discharge permitted under the zero-discharge standard and also indicates which flows are included in PolyMet's allowable discharge equation for purposes of the Project.

[7] Total flow from the Central Pumping Station (CPS) Pond to the FTB.

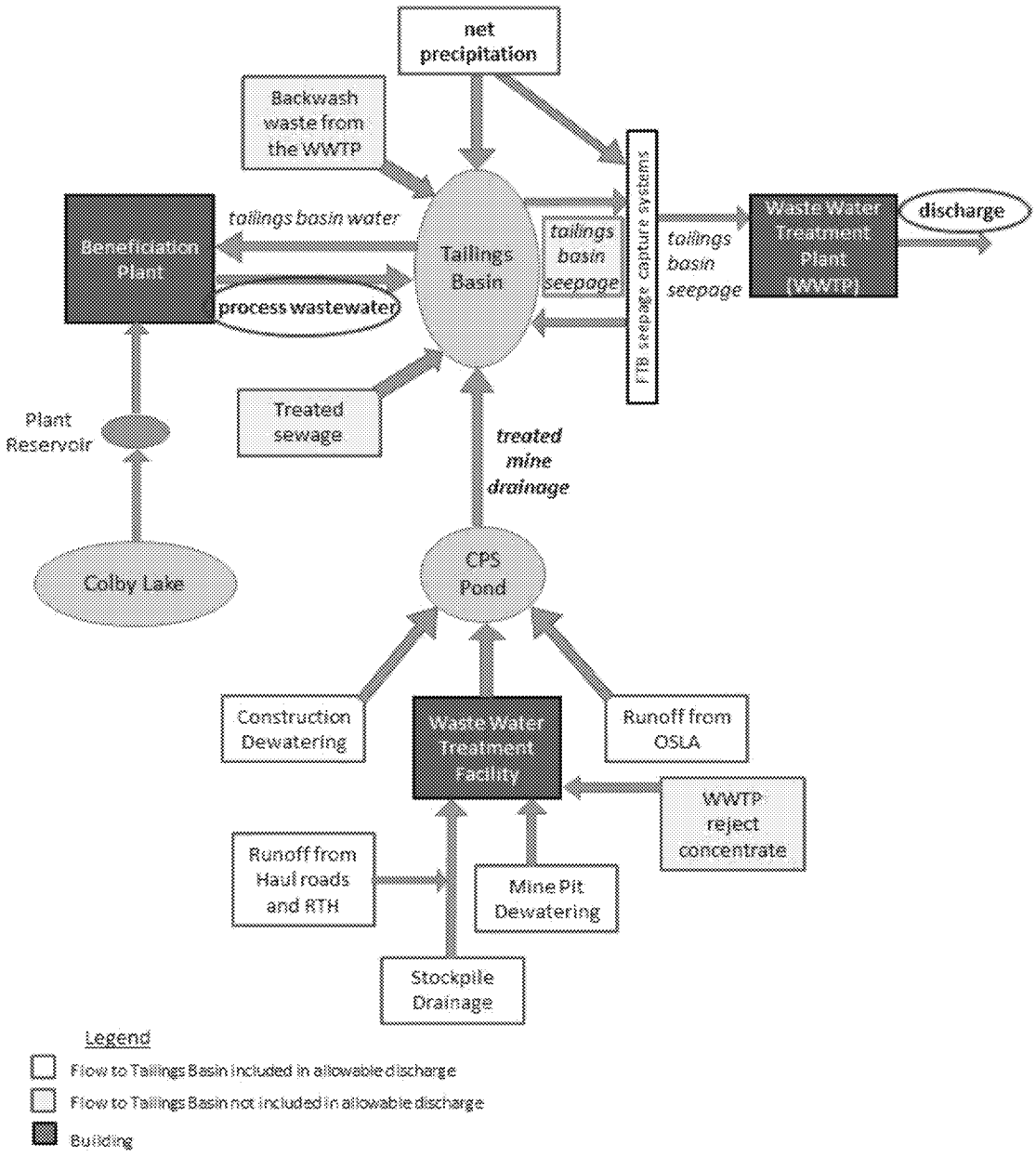

Figure 3 NorthMet Flows for Calculation of Allowable Discharge

4.2 Evaluating Compliance with "zero discharge" Requirements

Because the allowable discharge equation includes the volume of net precipitation, the calculation for the amount of allowable discharge is weather-dependent; the allowable discharge value will be smaller in dry years than in wet years.

The actual discharge from the WWTP is also weather-dependent. The actual amount the Project will discharge is determined by the amount of *tailings basin seepage* captured by the FTB seepage capture systems, minus the amount of captured seepage that is recycled to the FTB rather than sent to the WWTP for treatment. Precipitation in a given year affects actual discharge in subsequent years in two ways. First, an extended period of wet weather will result in additional infiltration, resulting in additional *tailings basin seepage* captured at the toe of the basin later. Second, when the water level in the FTB Pond is at the top of the design range, there will be less capacity to return captured *tailings basin seepage* to the FTB Pond.

The following analysis was conducted to determine how a range of weather conditions will affect both the allowable discharge and the actual discharge.

4.2.1 Zero-Discharge Modeling Method

The Plant Site GoldSim model developed for the FEIS was adapted for permitting to simulate the scenario in which the Mine Site and Plant Site experience a range of climatic conditions simultaneously. In the FEIS model, precipitation and evaporation were input into each model (Plant Site and Mine Site) as independent probabilistic variables, using a probability distribution based on the most recent climate normal period (1981-2010). The FEIS Mine Site model results defined a probabilistic range of flows from the Mine Site to the Plant Site, as an input for the Plant Site model.

For the zero-discharge modeling described in this memo, the Plant Site model was adapted to link net precipitation between the Plant Site and Mine Site. The Plant Site model was modified to correlate the amount of treated mine drainage received at the Plant Site (from the Mine Site) to the precipitation at the Plant Site. Specifically, the flow from the Mine Site to the Plant Site was perfectly correlated (value of 1.0) to the randomly generated precipitation in the Plant Site model. Therefore, for a year with a high rainfall amount, an equally high flow amount from the Mine Site was delivered to the Plant Site in the model, and vice-a-versa for low rainfall amounts.

Zero-discharge modeling for permitting was conducted using the adapted Plant Site model as follows:

- 500 model realizations were run of the period from Mine Year 1 through Mine Year 20. For each year, in each realization, the model randomly selected an annual precipitation value from a probability distribution derived from the most recent climate normal period (1980-2010).
- The allowable discharge was calculated within GoldSim using the formula shown in Section 4.1.3 at each monthly time step and for each of the 500 model realizations.
- The WWTP discharge was calculated within GoldSim, using the same conditions used for the FEIS, which set the minimum discharge volume at 1,700 gpm (based on the stream augmentation target) and the maximum discharge volume at 3,600 ppm (based on the maximum capacity of the WWTP). There was no change to the calculation method used for the FEIS; however, the monthly results differ slightly from the FEIS results because of the modeling change to link precipitation at the Mine and Plant Sites.

- For each monthly time step and each realization, the allowable discharge, the actual discharge, and the corresponding precipitation were exported from GoldSim into an Excel spreadsheet.
- The exported monthly results of the allowable discharge, the actual discharge, and the precipitation were further condensed into annual averages within Excel. This step created 500 realizations of annual results for each Mine Year.

4.2.2 Results

Allowable discharge increases when precipitation increases and as the sizes of the three mine pits and the FTB increase, as summarized in Table 3 and as shown in Figure 4 (Mine Year 1), Figure 5 (Mine Year 5), and Figure 6 (Mine Year 10).

Table 3 Allowable Discharge as a Function of Precipitation (gpm)

Precipitation	Mine Year 1	Mine Year 5	Mine Year 10
10th percentile (22.9 in)	1,780	2,320	2,340
50th percentile (27.8 in)	2,460	2,980	3,260
90th percentile (33.5 in)	3,140	3,740	4,180

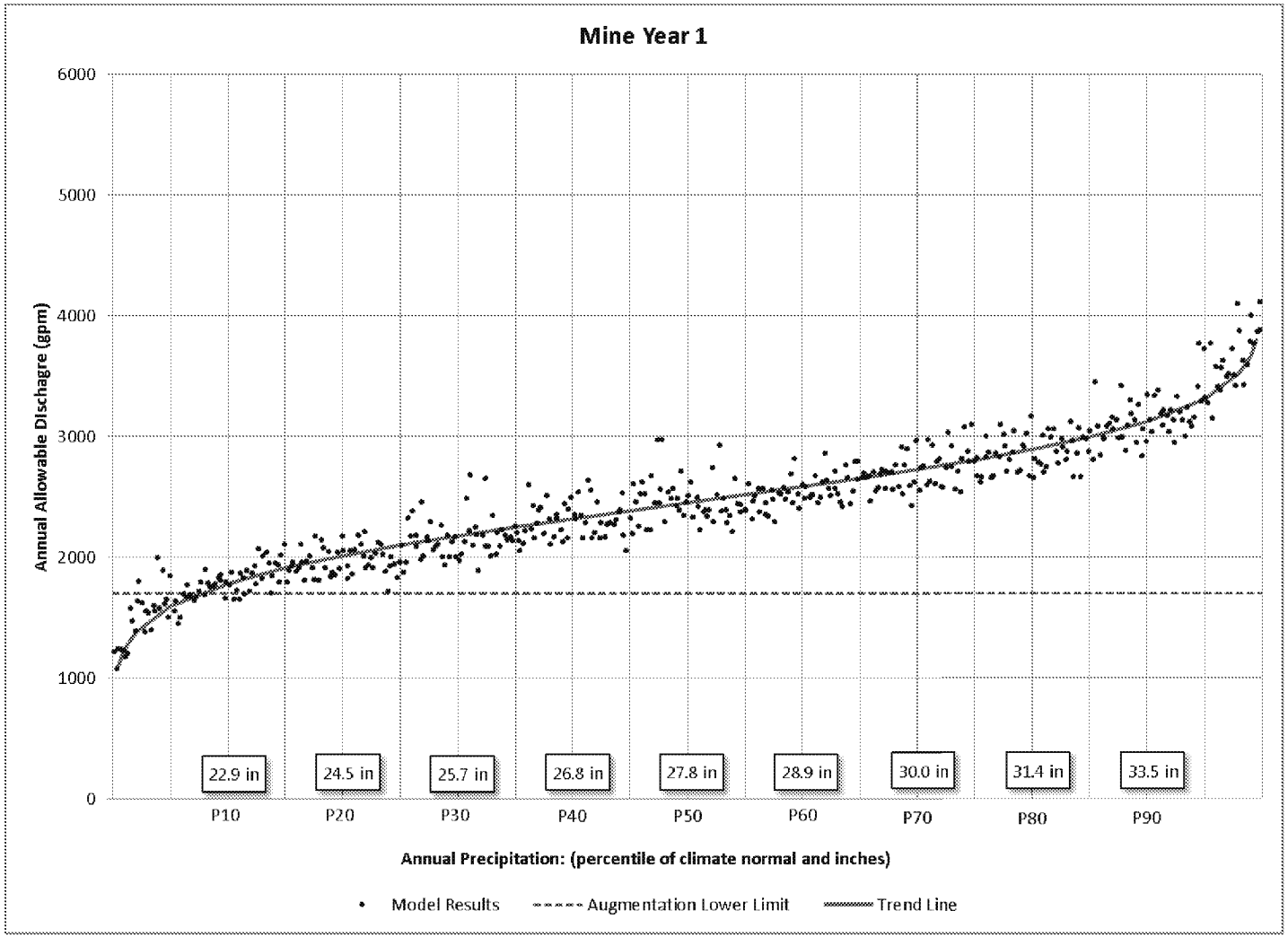

Figure 4 Allowable Discharge as a Function of Annual Precipitation, Mine Year 1

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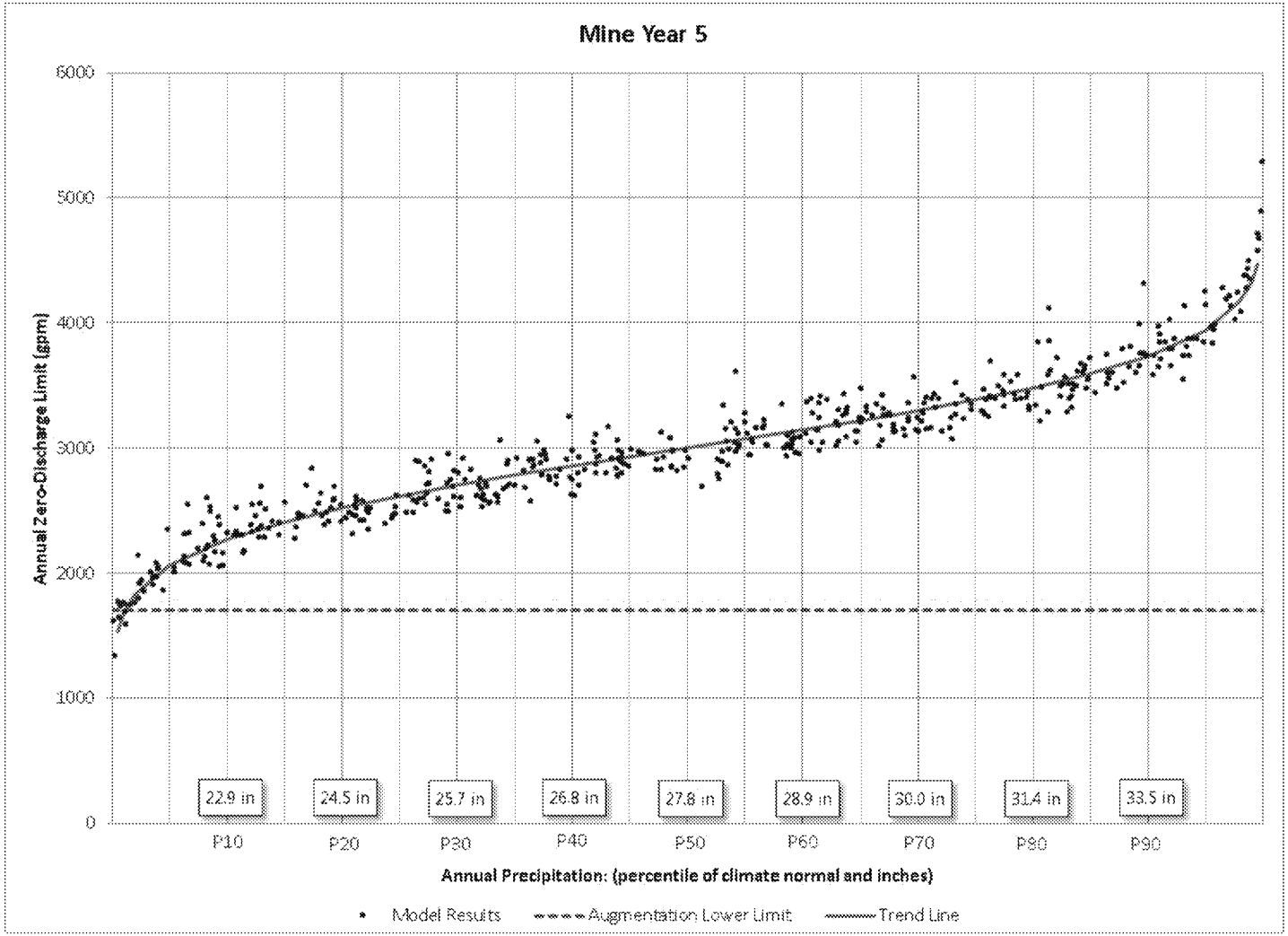

Figure 5 Allowable Discharge as a Function of Annual Precipitation, Mine Year 5

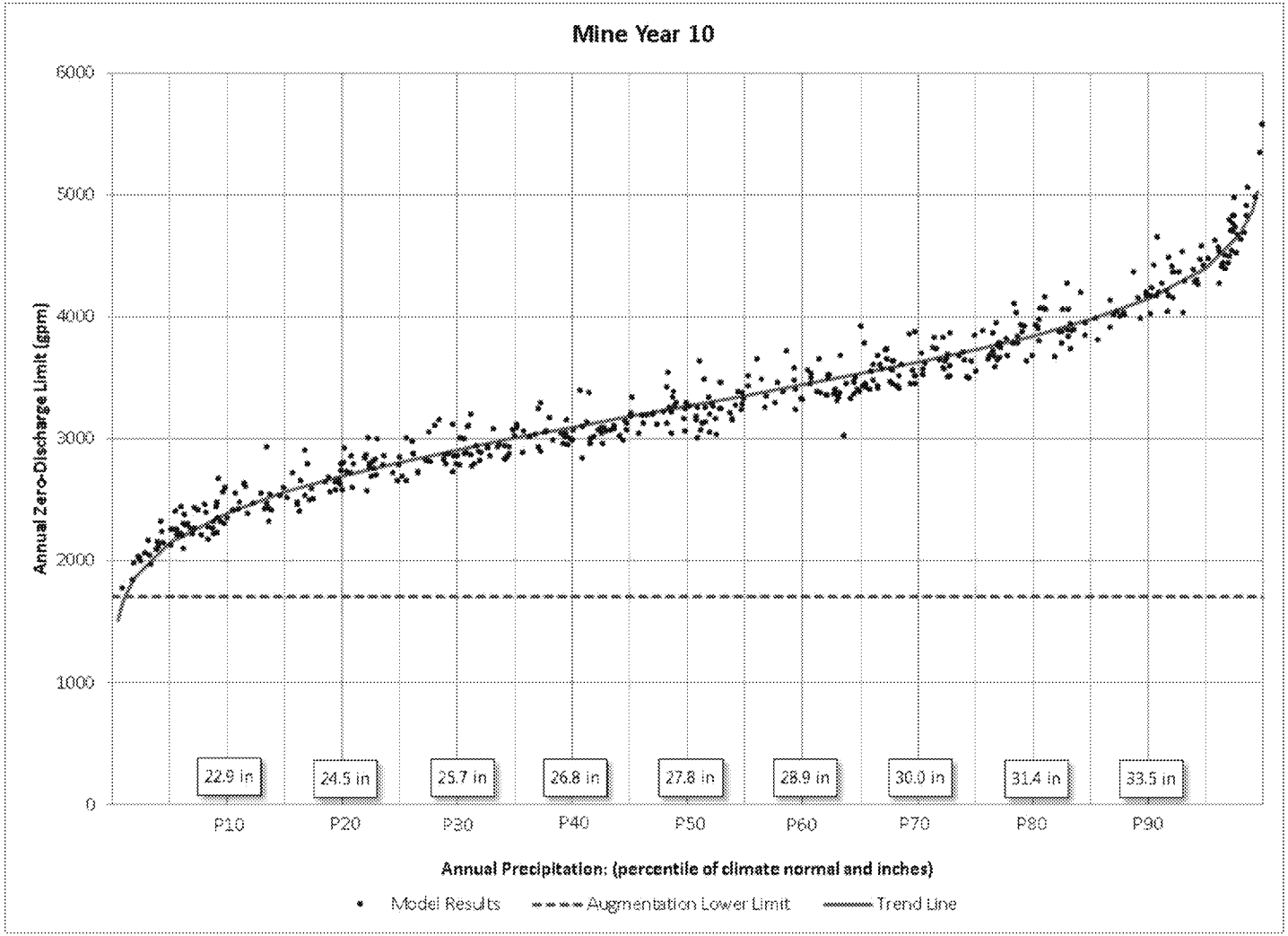

Figure 6 Allowable Discharge as a Function of Annual Precipitation, Mine Year 10

The total actual discharge volume will be less than the total allowable discharge volume over the life of the Project. Cumulatively, over the first five years of mining operations (approximately the first seven years of NPDES permit coverage), the actual discharge volume averages 64% of the allowable discharge volume. Over the 20-year operating life of the Project, the actual discharge volume averages 77% of the allowable discharge volume. Figure 7 shows the relationship between actual and allowable discharge volumes, cumulatively through Mine Year 5 and through Mine Year 20, based on the results of the Plant Site GoldSim model as adapted for permitting analysis of the "zero discharge" standard. This indicates that given the full range of precipitation included in the most recent climate normal period, the Project can comply with "zero discharge" requirements.

Barr also qualitatively considered potential effects of climate change on PolyMet's ability to comply with "zero discharge" requirements. During the environmental review process, PolyMet conducted sensitivity analysis to determine potential effects of climate change on flows from the Project. The FEIS Plant Site model was run using increased values of mean annual temperature, mean annual precipitation, and mean annual open water evaporation (Section 6.1 of Reference (3)). Results show that *tailings basin seepage* at the toes of the Tailings Basin is expected to increase slightly due to the increase in infiltration throughout the Tailings Basin; the total increased *tailings basin seepage* flow due to climate change as specified for the FEIS sensitivity analysis, would be about 60 gallons per minute (Reference (3)). This would represent an approximately 1.4% increase in seepage flow during Mine Year 10. Because the zero-discharge standard allows discharge of the volume of net precipitation, the projected increase in annual average precipitation is not expected to affect PolyMet's ability to comply with the "zero discharge" standard.

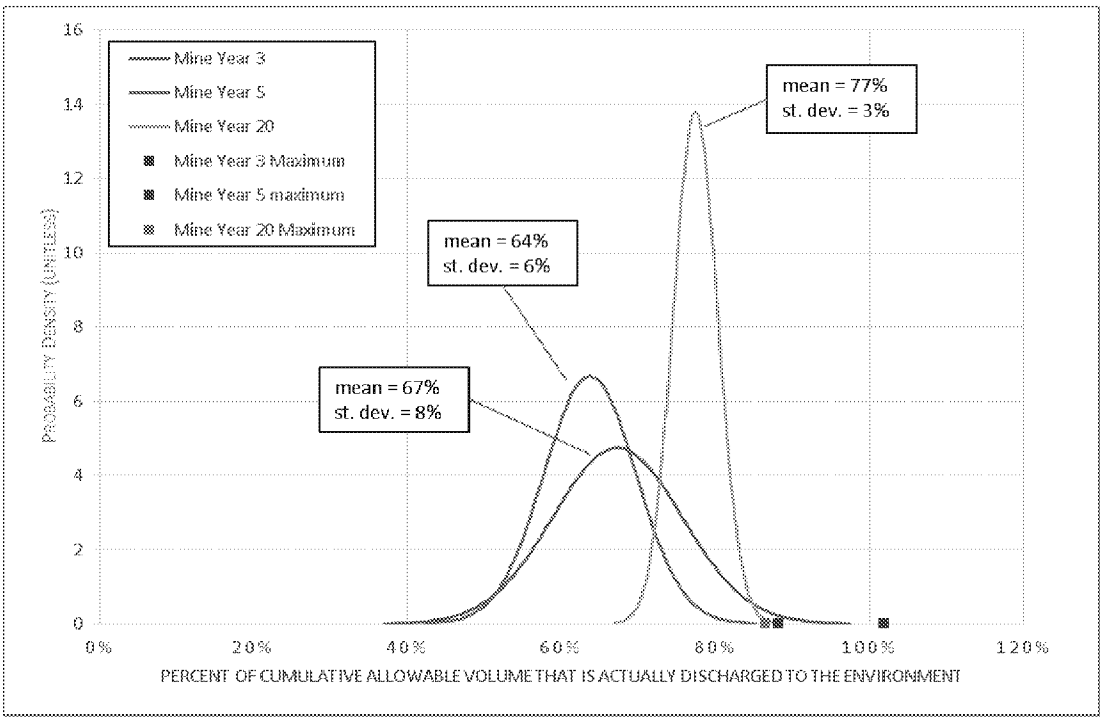

Figure 7 Percentage of Cumulative Allowable Discharge Volume That Will Actually Be Discharged

As previously discussed, the NSPS set forth in 40 CFR § 440 does not establish timeframes for calculating either allowable discharge or actual discharge for purposes of the "zero discharge" standard. PolyMet proposes that the NPDES/SDS permit adopt a multi-year approach for calculating these volumes so as to take into account timing considerations relative to variability in modeled weather conditions and timeframes for treatment of *process water*.

A multi-year approach is appropriate for the NorthMet Project. On an average annual basis, the actual discharge is estimated to be less than the allowable discharge in Mine Years 1 through 10, as shown in Figure 8.

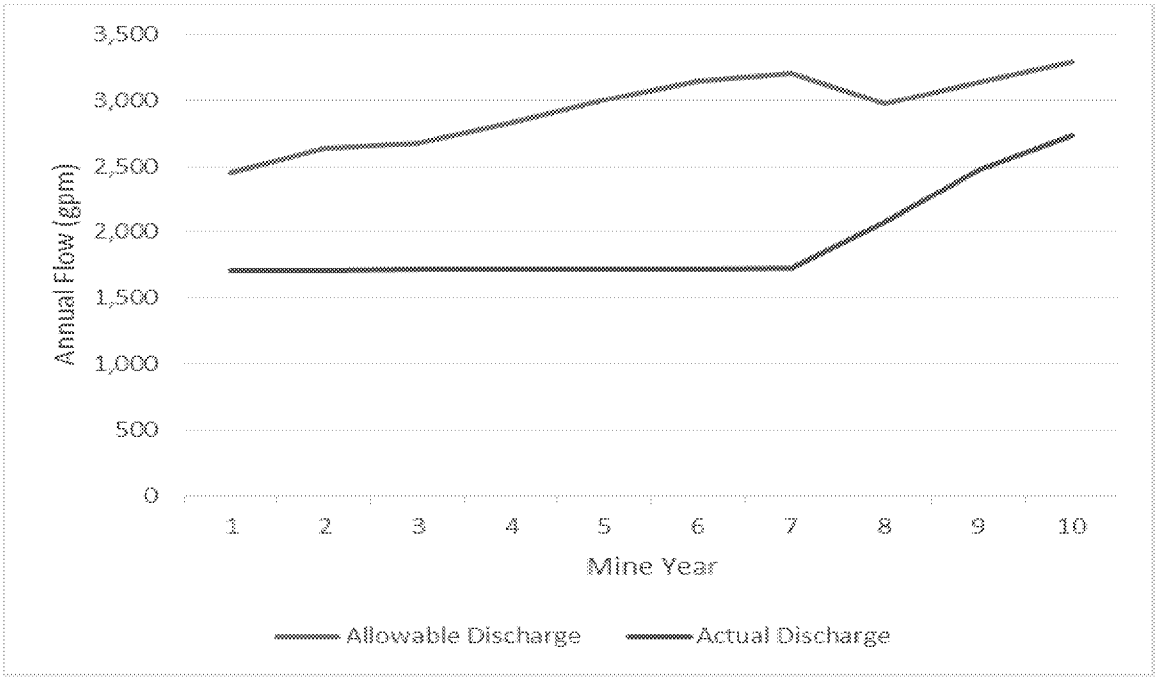

Figure 8 Allowable Discharge Compared to Actual Discharge: Annual Averages

Calculated as a five-year rolling average (which aligns with the five-year NPDES/SDS permit term), the Project can comply with NSPS "zero discharge" requirements over the range of modeled weather conditions. Figure 9 and Figure 10 show actual versus allowable discharge in Mine Years 5 and 10, calculated as 5-year rolling averages. Methods for demonstrating compliance during the first cycle of a multi-year rolling average period would need to be established during permitting.

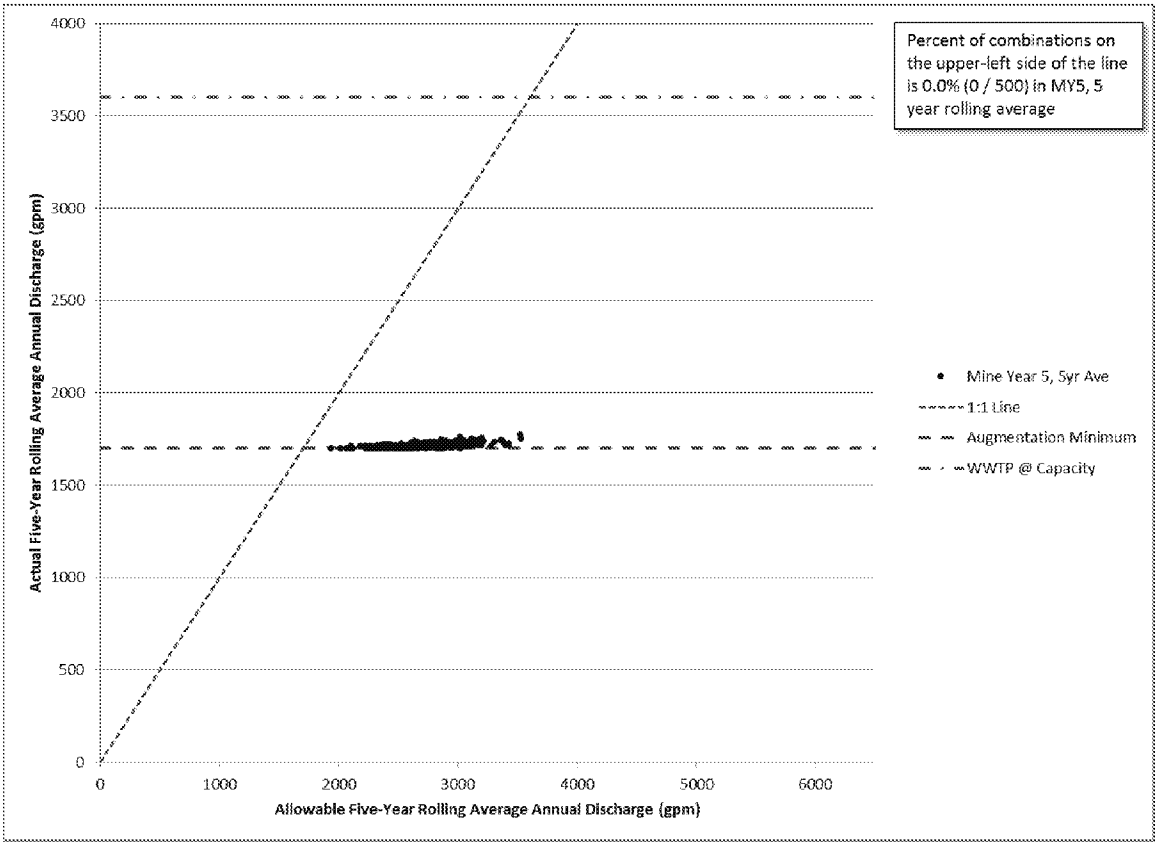

Figure 9 Actual Versus Allowable Discharge, Mine Year 5, 5-Year Rolling Average

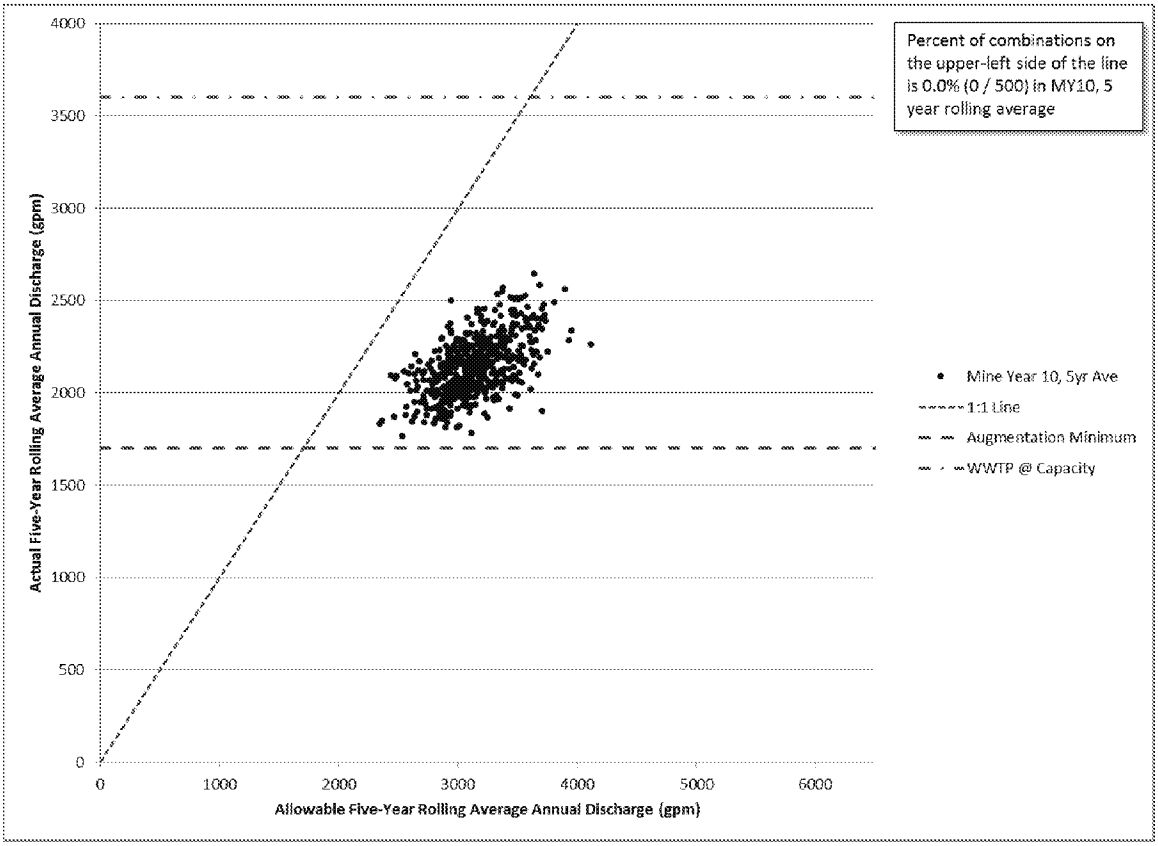

Figure 10 Actual Versus Allowable Discharge, Mine Year 10, 5-Year Rolling Average

5.0 Conclusion

The USEPA's new source performance standards under the Clean Water Act contain a general prohibition against discharging process wastewater to waters of the United States from new mills that use the froth-flotation process for the beneficiation of copper, lead, zinc, gold, silver, and molybdenum ores (40 CFR § 440.104(b)(1)). While this general prohibition is referred to as the "zero discharge" standard, the applicable law includes certain exceptions that allow a certain volume of discharge to account for specific conditions and does not prohibit discharge of mine drainage. The NorthMet Beneficiation Plant and WWTP discharge, as proposed by PolyMet, can comply with this "zero discharge" standard.

As outlined above, modeling demonstrates that the Project will discharge less than the allowed amount of process wastewater during the first 5 years of operations (approximately the first 7 years of NPDES/SDS permit coverage) as well as over its 20-year operating life. Further, calculated as a 5-year rolling average, the Project will comply with "zero discharge" requirements for the full range of modeled weather conditions. Possible future climate trends toward increased precipitation during the life of the Project are not expected to affect compliance, because the "zero discharge" standard allows discharge of net precipitation. Therefore, Barr concludes that the Project can comply with the NSPS "zero discharge" standard.

6.0 References

1. **Poly Met Mining Inc.** NorthMet Project Water Modeling Data Package Volume 2 - Plant Site (v11). March 2015.

2. —. NorthMet Project Water Modeling Data Package Volume 1 - Mine Site (v14). February 2015.

3. **Barr Engineering Co.** Sensitivity Analysis of the NorthMet Water Quality Models (v2). January 2015.

4. **U.S. Environmental Protection Agency.** Ore Mining and Dressing Point Source Category Effluent Limitations Guidelines and New Source Performance Standards. Rules and Regulations. 40 CFR Part 440. [WH-FRL-2232-1]. December 3, 1982.

5. —. Development Document for Final Effluent Limitations Guidelines and New Source Performance Standards for the Ore Mining and Dressing Point Source Category. November 1982.